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Digital Divide: Determinants and Policies with Special Reference to Asia

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Foreword

The ERD Working Paper Series is a forum for ongoing and recently completed research and policy studies undertaken in the Asian Development Bank or on its behalf. The Series is a quick-disseminating, informal publication meant to stimulate discussion and elicit feedback. Papers published under this Series could subsequently be revised for publication as articles in professional journals or chapters in books.

Abstract

Access to new information and communication technologies (ICT) remains extremely unequally distributed across and within societies. While there have been a good deal of popular discussions about this “digital divide”, not much is known about the quantitative significance of its various determinants. By undertaking a set of cross-country regressions, the paper finds that income, education, and infrastructure play a critical role in shaping the divide. Based on this analysis, the paper also offers some policy suggestions as to how to promote wider diffusion of ICT in poorer societies.

Contents

I. INTRODUCTION

Much has been written about the digital divide: the division of the world between those who have access to new information and communications technology (ICT) and those who do not. This inequitable access to ICT has implications for productivity and economic growth of rich and poor countries. For example, the United Nations Development Programme (1999, 63) notes: "The network society is creating parallel communications systems: one for those with income, education and literacy connections, giving plentiful information at low cost and high speed: the other are those without connections, blocked by high barriers of time, cost and uncertainty and dependent upon outdated information." Similar concerns have been expressed by such authors as Dertouzos (1997) and Sachs (2000) with the latter claiming that a new map of the world has been created, this time based on technology. However, there are many others who are much more optimistic. For example, Negroponte (1998) opines that ICT has a "leapfrogging" characteristic that will enable the poor to catch up. As latecomers, developing countries can embrace existing technologies developed elsewhere and skip intermediate stages allowing them to save on considerable costs of development. In light of the contending viewpoints, it is important to learn what the basic economic determinants of the digital divide are and the ways to overcome it.

The organization of this paper is as follows. Section II provides a brief discussion of the various types of ICT, which constitute the backbone of the digital economy. Section III is devoted to a discussion of the determinants of ICT adoption. The quantitative analysis provided in this section suggests that there is a strong association between ICT adoption with the socioeconomic characteristics of the country. In light of this discussion, the paper makes in Section IV some inferences about the policy choices for developing countries that would like to promote ICT adoption. The discussion of this section is primarily focused on Asian countries. However, despite the particular empirical focus of the present analysis, it is hoped that the insights from this analysis would be equally applicable to other parts of the developing world. The paper provides some concluding remarks in Section V.

II. TYPES OF ICT

Depending on the type of use, the new ICT can be roughly divided into three broad categories, that is, ICT for (i) computing, (ii) communication, and (iii) Internet-enabled communication and computing.

With the invention of computers, which represents the most significant technological breakthrough of the last half of the 20th century, the cost of computing has declined exponentially over the years. And the usage of computers has increased by leaps and bounds with the introduction of personal computers. At the most general level, computers augment and improve thinking capabilities of individuals and organizations and enhance their efficiency. One important example relates to the business management system, known as “enterprise resource planning” (ERP), where new softwares enable firms to efficiently integrate all facets of business, including planning, manufacturing, sales, and marketing. Another example of an important use of computing is computer-aided manufacturing and computer-aided design (CAD/CAM) in the product design for the manufacturing process. This process has radically improved product lifecycles—in particular, it has reduced the time lag between conceptualization of the product and its entry into the market—as well as the quality and complexity of product design.[1]

Communication, which is one of the most important aspects of modern human life, has two broad categories: one-way and two-way communication. The most common form of communication is one-way communication, which includes the broadcasting media like radio and television. Two-way communication devices, which include faxes, telephones, telegraphs, and pagers, have improved significantly over the last two decades or so. The Internet’s growth is largely a function of two-way communication links: between telephone lines and personal computers (PCs). However, in most developing countries, mobile telephones are easier to obtain than traditional fixed landline telephones. Therefore, the movement of the Internet and Internet applications into mobile phone systems will have a tremendous technological implication for these countries.

The Internet, including the World Wide Web, is one of the most important technologies to affect both communication and computing. The Internet provides, on one hand, a new communication medium that allows activities like e-mail or chat lists for group communication, and on the other, multiple modes of communication by fostering new interfaces between new and old forms of communication. For example, one can now communicate via voice to others through Internet telephony, or use mobile phones to access the Web. The Internet also provides communities with a whole new means of communication (i.e., many-to-many point communication such as chat lists and discussion forums), and collaborative platforms. The World Wide Web, where people can search for and obtain information on the Internet, enables people to post messages, create home pages, and communicate with many others.

The Internet not only provides individuals with access to more information but also facilitates new ways of representing information (multimedia), structuring information (through hyperlinks), and creating information (through collaborative and distance work). Unlike many other media that treat users as passive, the Internet is an active medium that demands a greater degree of sophisticated thinking and logical skills.

The rapid transformation of the Internet, as it moves beyond PCs into palmtops, mobile phones, and appliances, has radically changed not only communications but also commerce and computing in all fields, including scientific computing and business automation. Already, Bluetooth

[1] An important advantage of CAD/CAM over conventional designs is its ability to transfer information regarding designs readily and accurately across organizational and national boundaries without distortions. In recent years, the use of CAD/CAM has become widespread in multinational enterprises across the world.

technological standards and devices allow any device to electronically “talk” to another device through wireless systems, including the wireless Web, cell phones, and laptops. With the advent of new ICT, e-commerce has increased rapidly along with trade in information products. In business, the simple automation of business processes like accounting and payroll, and the subsequent integration of these functions via ERP software, are being gradually replaced by Web-based inter-enterprise or intra-enterprise ERP, supply chain management, auctions for procuring supplies, and the like.

III. DETERMINANTS OF ICT ADOPTION

The status of ICT adoption of an economy is an indicator of its potential ability to exploit the economic opportunities afforded by the new technologies—or more generally, its prospects for transition to the “new economy.” As expected, the adoption of ICT varies significantly across countries. Like anywhere in the world, Asian countries have experienced a rise in the use of personal computers in recent years, though the degree of expansion has varied between countries.

Table 1 shows the most recent estimates of the numbers of PCs among Asian developing countries. The newly industrialized economies (NIEs) are, quite expectedly, heading the pack and their figures are comparable to those of the advanced countries. For example, Singapore has 527.2 personal computers per thousand people in 1999, which is 1.8 times the figure of Japan in the same year. The rest of the developing countries, including India, which has achieved a large measure of international success in software development, have far fewer numbers of personal computers per capita, compared to the NIEs. The South Asian countries appear to have the lowest per capita computers in the list, ranging from one computer per thousand people in Bangladesh to 4.3 computers in Pakistan.

Along with personal computers other indicators of ICT diffusion in an economy include usage of televisions, main line telephones, mobile phones, fax machines, and Internet. Table 1 provides a picture of ICT diffusion across Asian countries. Whether it is the use of cellular phones, main line telephones, or the Internet, their distributions across countries follow a pattern similar to per capita ownership of PCs. The striking picture that emerges from Table 1 is one of extreme inequality—one of the haves and the have-nots—representing a stark digital divide between countries.[2]

[2] It is estimated that more than 75 percent of Internet users live in high-income economies, which contain only 14 percent of the global population. Internet use in countries like Iceland, Norway, Sweden, and United States has already reached more than half the population. This is in stark contrast with the rest of the world. For example, Internet use in South Asia is only 0.4 percent of its population (UNDP 2001).

Table 1. **ICT Diffusion in Selected Asian Economies (per thousand people)**

Economies	Telephone Main Lines (1999)	Cellular Phones (1999)	Personal computers (1999)	Internet Users (2000)
Developing Asia				
Bangladesh	3.4	1.2	1	0.2
People's Republic of China	85.8	34.2	120	13.4
India	26.6	1.9	3.3	4.5
Indonesia	29.1	10.6	9.1	1.8
Kazakhstan	108.2	3	n.a.	4.2
Kyrgyzstan	76.2	0.6	n.a.	2.1
Malaysia	203	137	68.7	68.8
Nepal	10.6	n.a.	2.6	1.4
Pakistan	22.2	2.1	4.3	8.5
Philippines	39.5	36.6	16.9	6.2
Sri Lanka	36.4	12.2	5.6	3.4
Thailand	85.7	38.4	22.7	16.5
Viet Nam	26.8	4.2	8.9	1.3
Industrial and Newly Industrializing Economies				
Japan	494	449.4	289.6	213.8
Hong Kong, China	577.5	636.1	290.5	260
Singapore	482	418.8	527.2	419.1
Korea	441.4	504.4	189.2	323.1
Taipei,China	545.2	522.4	180.7	288.4
United States*	681.8	311.5	510.5	537.2

*Estimates for the United States were included for comparison.
n.a. means data not available.
Sources: International Telecommunication Union (2000) and Nua Internet Surveys (2000).

Why is there a stark divide? What are the basic economic determinants of ICT diffusion? Are the determinants of adoption and diffusion different in developing Asia from the rest of the world? To address these queries, we undertook a set of elementary regression exercises covering more than 100 countries. These exercises cover a varying number of observations per indicator of ICT diffusion depending on the availability of cross-country data. An Asian dummy was included in each of the regression equations to determine the extent of variation in ICT diffusion in the region from the rest of the world. However, due to lack of disaggregated data, this discussion does not make any distinction between different usages of ICT: whether it is used as a consumption or production item. While the quantitative results are tentative, they are highly suggestive and seem to be in broad sympathy with the results available from advanced countries such as Japan and the United States (US).

How do country characteristics such as income and population size affect the use of ICT? Simple regression analysis suggests the following. First, computer usage is strongly correlated with GDP per capita, with an income elasticity of computer usage exceeding unity (see Table 2). Similarly, Internet use is highly correlated with income, with income elasticity being nearly 2. The usage of other types of ICT (fax machine, telephone main lines, television, cellular phone) is highly income-elastic. Second, as far as population size is concerned, regression analysis does not suggest any additional benefit from a larger size as far as personal computer, telephone main line, and Internet use is concerned. However, when income is controlled, the use of cell phones and televisions appears to increase with the rise of population. This may reflect the simplicity of the technology involved and their easy availability for purchase in most countries. Third, in all cases, the Asian dummy was insignificant, implying that these relationships are not substantially different in Asia from the rest of the world.

Table 2. **ICT, Income, and Population**

Variables	Population	Income	Asia	R^2	Observations
Cellular Phone	1.065***	1.882***	-0.191	0.86	145
	(25.617)	(25.310)	(-0.810)		
Fax Machine	-0.152	1.524***	0.007	0.60	75
	(-1.783)	(11.698)	(0.017)		
Internet Use	0.009	1.897***	-0.335	0.81	153
	(0.220)	(28.904)	(-1.536)		
Personal Computer	-0.098 ***	1.613***	0.024	0.88	90
	(-2.999)	(27.035)	(0.222)		
Telephone Main Line	-0.056**	1.441 ***	0.083	0.86	144
	(-2.319)	(31.807)	(0.563)		
Television	1.061***	2.657 ***	0.492	0.86	57
	(8.664)	(15.132)	(1.573)		

Notes: T-statistics are in parenthesis; ***, ** and * indicate statistical significance at the 1, 5, and 10 percent level, respectively. Standard errors are corrected for heteroscedasticity by using the method proposed by White (1980). All variables are in per capita and in logarithms. For Asia dummy, Asia equals 1 and 0 otherwise. Income is per capita income in purchasing power parity.

Sources: International Telecommunication Union (2000) and Nua Internet Surveys (2000).

How does education affect the adoption of ICT? Simple regression results, as reported in Table 3, suggest the following. The relationship between computer usage and education is statistically significant at the 1 percent level with tertiary education. The same is true as far as Internet use is concerned. Moreover, secondary education is also significant at the 1 percent level for telephone. It may be noted that the firm-level evidence from Japan and the US confirms the complementarity of tertiary education with ICT use (Bresnahan, Brynjolfsson, and Hitt 1999). For other types of ICT, such as cellular phone, fax machines, and television, education does not play any significant part.

Table 3. **ICT, Income, and Education**

Variables	Income	Primary	Secondary	Tertiary	R^2	Observations
Cellular Phone	1.882***	0.004	-0.008	0.007	0.85	106
	(9.148)	(0.812)	(-1.174)	(0.800)		
Fax Machine	1.652***	0.014	-0.013	0.015	0.70	59
	(5.688)	(1.548)	(-1.071)	(1.560)		
Internet Use	1.490***	-0.001	0.012	0.028***	0.88	56
	(6.481)	(-0.007)	(1.252)	(2.921)		
Personal Computer	1.443***	0.004	0.001	0.008***	0.93	68
	(15.725)	(0.661)	(0.376)	(2.804)		
Telephone	0.917***	0.001	0.018***	0.001	0.89	107
	(9.412)	(0.145)	(4.169)	(0.194)		
Television	2.479***	0.018	0.002	-0.007	0.85	49
	(4.521)	(1.209)	(0.210)	(-0.534)		

Notes: T-statistics are in parenthesis; ***, ** and * indicate statistical significance at the 1, 5, and 10 percent level, respectively. Standard errors are corrected for heteroscedasticity by using the method proposed by White (1980). All variables are in per capita and in logarithms, except percentages. For Asia dummy, Asia equals 1 and 0 otherwise. All regressions include a population control, which is not reported. Income is per capita income in purchasing power parity. All the regressions include an Asia dummy that is statistically insignificant, and a population control, both of which are not reported.
Sources: International Telecommunication Union (2000), World Bank (2000), and UNESCO (2000).

Is there any complementarity between different types of ICT? Table 4, which reports a set of simple regression results, suggests the following. First, telephone use is strongly correlated with PC and Internet use. Internet has high correlation with telephone largely reflecting their complementary nature.

Table 4. **Complementarity between Technologies**

Variables	Income	Telephones	R^2	Observations
Cellular Phone	1.884*** (7.451)	0.030 (0.173)	0.87	133
Internet Use	1.251 *** (6.009)	0.459 *** (3.475)	0.83	138
Personal Computer	1.206*** (6.670)	0.344** (2.219)	0.90	85
Television	1.653** (2.421)	0.680 (1.496)	0.87	56

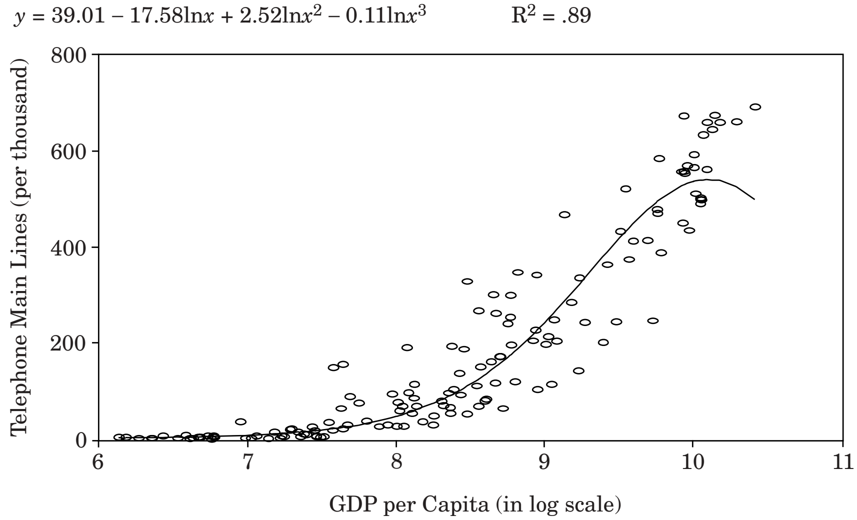
Notes: T-statistics are in parenthesis; ***, ** and * indicate statistical significance at the 1, 5, and 10 percent level, respectively. Standard errors are corrected for heteroscedasticity using the method proposed by White (1980). All variables are in per capita and in logarithms. For Asia dummy, Asia equals 1 and 0 otherwise. Income is per capita income in purchasing power parity. All the regressions include an Asia dummy that was statistically insignificant, and a population control, both of which are not reported.
Sources: World Bank (2000) and International Telecommunication Union (2000).

Second, as expected, there is no complementarity between telephone use and television use and between telephone use and cellular phone use. Third, the correlation between Internet usage and income level increases when controlled for telephones. This suggests that in the presence of a well-developed telephone infrastructure, income level becomes the principal determining variable.

Finally, our cross-country regression analysis suggests the existence of a nonlinear relationship between income and telephone lines. This relationship indicates that there is a serious dearth of telephones at low-income countries, but after a country reaches a threshold income level, telephones become relatively commonplace. Figure 1 represents this relationship, which is a third degree polynomial with statistically significant coefficients. Among the Asian economies, the NIEs have the highest per capita availability of telephones, somewhat comparable to other advanced countries. There may be two different reasons for this distinct separation among countries in terms of telephone use. The first reason relates to supply factors: it simply reflects the fact that higher-income countries may have well-developed infrastructures. The second reason relates to demand factors: it reflects the benefits of the so-called network externality. That is, the benefits of getting a telephone rise as the number of people with telephones in the economy increases.

In short, it appears that the principal determining factors for the diffusion of ICT in developing countries are income and investments in human resource and infrastructure development. However, the degree of influence of these variables is not uniform across the various types of ICT.

Figure 1. **Relationship between Telephones and Income Per Capita**



Sources: World Bank (2000) and International Telecommunication Union (2000).

IV. POLICIES TO PROMOTE ICT

While there is a close interconnection between income and ICT diffusion, this relationship is not a watertight one. The performance of many countries is better than what is warranted by their per capita incomes (whereas that of many others is worse than what is warranted by their per capita incomes). This can be seen from the divergences of individual country performances from the international averages for their respective income levels. In this paper we calculate such divergences for the Internet, the principal component of the new ICT revolution. The international "average" line was derived by regressing Internet adoption against per capita income of the countries expressed in purchasing-power-parity terms. Table 5 shows the estimates of divergences for a number of Asian countries. These divergences from the averages are largely the result of relevant physical and social investments promoted by these countries. Some countries have underinvested compared to their international averages for that income level. These countries need to increase their investment levels in those activities if they do not want to fall behind their "comparator" countries in adoption and diffusion of ICT. That would also require, among others, getting their relevant policies and institutions right.

Table 5. **Internet Access in Selected Economies: Actual versus Predicted (per 10,000 people)**

Economy	Internet Access, Actual	Internet Access, Predicted	Difference: Actual - Predicted
Developing Asia			
Bangladesh	2	-164.04	166.04
Bhutan	2	-138.84	140.84
People's Republic of China	134	87.10	46.90
India	45	-60.93	105.93
Indonesia	18	21.72	-3.72
Kazakhstan	42	270.41	-228.41
Kyrgyzstan	21	-26.37	47.37
Malaysia	688	811.71	-123.71
Maldives	6	227.93	-221.93
Nepal	14	-193.41	207.41
Pakistan	85	-113.06	198.06
Philippines	62	151.90	-89.90
Sri Lanka	34	68.96	-34.96
Thailand	165	425.64	-260.64
Viet Nam	13	-116.80	129.80
Industrial and Newly Industrializing Economies			
Japan	2138	2988.99	-850.99
Hong Kong, China	2600	2629.85	-29.85
Singapore	4191	3126.22	1064.78
Korea	3231	1580.81	1650.19
United States*	5372	3903.10	1468.90

Notes: The predicted values for Internet use in column three are derived from a cross-country regression analysis for 157 countries between Internet use and GDP per capita in purchasing-power-parity exchange rate. The estimated equation $y = 0.144x - 360.02$, with $R^2 = 0.75$ is statistically significant at conventional levels. Positive numbers in column four in the table indicate that the countries are actually using more Internet services than they are predicted to use at their income levels in relation to international averages for those income levels.

*Estimates for the United States were included for comparison.

Sources: World Bank (2000), International Telecommunication Union (2000), and Nua Internet Surveys (2000).

A. Investment in Education

As our earlier analysis suggests, the relationship between education and ICT is critical. Education is important because it provides the skills required for creating, adapting, and utilizing such technologies. This is not to deny that even the illiterate or near-literate can possibly take advantage of certain technological applications. But to go beyond elementary applications, education becomes increasingly important. Indeed, international evidence suggests that education is a strong complement to Internet use and that the relevant educational levels are secondary and tertiary levels as they are expected to upgrade the national capacity for adaptation and innovation.[3] Therefore, if a country aspires to exploit in significant ways the opportunities offered by new ICT, particularly the creation of new industries, it needs to emphasize secondary and tertiary education. This lesson is in contrast with conventional wisdom that poorer countries should emphasize primary education that yields the higher rate of social returns to these countries (Psacharopoulos 1994). However, in most poor developing countries where illiteracy abounds and the importance of ICT-related industries has not reached a significant level, it may be premature to overturn the conventional wisdom.

Those developing countries that have already reached universal primary education for their citizens should place more emphasis on secondary and tertiary education, particularly focusing on science, mathematics, engineering, and computing if they want to take advantage of new ICT opportunities. Nevertheless, one does not need to rely exclusively on the government for promoting secondary and tertiary education. Many individuals who would like to take advantage of ICT opportunities are economically well off and may not need government financial assistance. For others, improved availability of student loans from the financial system can be a major help in financing their educational expenses.

In addition to formal education, a rapidly changing technology like ICT would require continuous training on the part of the workforce. But the principal responsibility of imparting such training should lie with the concerned firms in line with their requirements. However, the government can also play an important part in inducing the firms to impart such training through various types of tax incentives (UNDP 2001).

B. Investment in Infrastructure

For a country to succeed in ICT, one critical element is physical infrastructure in telecommunications links. The government has an important role in creating such infrastructure, especially in the poorer countries. This role stems from a number of important considerations. First, in very poor countries, the market forces may be shy both because of lack of effective demand and because of lumpiness of investment.

Second, even in countries where the private sector is not shy, the government has to play the role of a catalyst and a regulator. It appears that there are potentially many opportunities for fostering partnerships in the creation of infrastructure. To attract the private sector, the government may have to play the role of a catalyst by instituting various innovative incentive mechanisms such as build-own-operate, build-own-transfer, etc. Even when the private sector is already there, the government has an important function as a regulator. It may be noted that the telecommunications industry, which constitutes the basic infrastructure for ICT, is a natural monopoly.

[3] Much of the Internet-based information is textual and in English. In many developing countries, a significant proportion of the rural population is either illiterate or has an education no higher than the elementary level. Therefore, a large segment of the rural population may not be able to access and comprehend the Web-based information.

Third, despite the strong case for a competitive market in ICT, many countries still maintain strong barriers against entry. This entry barrier, along with the heavy government involvement in such ICT-related sectors as telephones, has spawned pervasive corruption in many developing countries and has hiked up costs of communication. Privatization or deregulation would be the most efficient response to such a conundrum. Keeping their markets open to foreign trade and investment augurs well for the development of the ICT industry. Openness speeds up transfer of technology and encourages investments on ICT. It has been suggested that multinational companies as well as local firms take into account the existence of ICT networks as one of the requirements for investments.

Fourth, governments in developing countries should foster an environment that would encourage innovation through research and development. It may be noted that developed countries that have established their lead in the ICT realm have invested heavily in research and development (R&D). In the period 1992-1997, R&D in countries of the Organization for Economic Cooperation and Development accounted for 1.8 percent of GDP while that in East Asia and South Asia averaged 0.8 percent in the same period (Rodriguez and Wilson 2000). With fiscal incentives and proper enforcement of property rights, the private sector would have the impetus to engage in R&D activities. However, in areas where the market fails, particularly in basic research, the government should take the lead. Aside from direct investments in R&D, the government can encourage research linkages between universities and the ICT industry. However, not every country can be in the cutting edge of technology. For most developing countries, which are followers in the technology field, the focus of R&D efforts should be in the area of adaptation of technologies according to local needs and conditions.

Finally, the government can play an important role in ensuring the telecom network standard. In many developed countries in Europe, the fortuitous outcome of a uniform network has come through the dominance of a single company or through the cooperation of several strong companies. But the situation is not so fortuitous in many other countries where a total chaos or near chaos, in terms of standards, prevails. In the US, several incompatible mobile communications standards exist side by side. In developing countries, the government can play a more proactive role in circumventing such chaotic outcomes by imposing socially optimal standards.

C. Creation of Favorable Institutions

For those countries that seek to play an important role in the development and export of ICT items such as software, they need to foster an institutional environment conducive to such development. An important element of such an environment that would foster investment and harness creativity relates to adequate protection of property rights, enforcement of contracts, rule of law, and personal autonomy etc., without which the economic incentives of firms to invest or innovate would be largely eroded. These institutional aspects, which are an important prerequisite for the successful adoption of new ICT but are often weak in poorer countries, need to be improved. But at the same time, the new ICT ideas are often interconnected and draw on each other's concepts, which makes the task of defining the ownership of the intellectual product as well as appropriating the benefits all the more difficult. The task of defining intellectual property and the appropriate mechanism for protection has been the subject of good deal of discussion. When such "property" can be defined, one well-known method of protecting such property is of course the granting of patent rights, which offers the right incentives to the creators. However, as is well known, such a policy creates at the same time a large element of distortion (because of the monopolistic nature of production) and may sometimes act as stumbling blocks to future innovations. Other methods to encourage innovation include a recent proposal by Kremer (1998) who suggests the introduction of a system of prizes based on what the private firms would pay for the monopoly to produce the item in question. While this is an interesting proposal, it involves substantial public expenditure on rewards for countries that are otherwise financially constrained. In any case, whatever approach the government takes to manage innovation, the wrong approach would be to micromanage it.

If certain types of ICT are considered socially desirable merit goods (for example, those items related to education, etc.), a case can be made for their wide diffusion among the populace. However, diffusion of useful ICT technologies is likely to involve substantial positive externality. In these circumstances, a case may be made for subsidization of ICT use like undertaking efforts to establish communal access to specific types of ICT.

Similarly, research suggests that the use of ICT has been most productive in firms with a flat and less hierarchical organization structure. This type of organization is more common in the US than elsewhere in the world. One way to promote such an organizational structure is by keeping markets open and competitive (Cohen, De Long, and Zysman 2000). The government policy should therefore avoid pursuing policies that foster a closed and monopolistic environment in the name of "nurturing the infant industry."

D. Fostering New Institutional Innovations

For developing countries, it is difficult to provide first-class infrastructure for the whole country. One way to circumvent the problem is to create special "technology parks" to cater to the specific needs of the ICT industry. These high-tech locations offer superior infrastructure (such as uninterrupted power supply, satellite downlinks, etc.), provide many fiscal incentives (tax holidays etc.), and assure investors of expeditious government approvals and other logistic assistance.[4]

[4] Some technology parks have achieved considerable success. The Singapore Science Park hosts more than 200 IT-related R&D firms. India has developed a number of such parks in Bangalore, Hyderabad, Mumbai, and Chennai. Another notable example is Taipei,China's Hsinchu Park, which has an area of 580 hectares and employs more than 70,000 R&D staff. Malaysia's Multimedia Super Corridor is a more recent high-profile addition. In the Philippines, Metro Manila hosts a number of such technology parks, which are becoming the data center hub for many foreign companies. Meanwhile, the Zhong-Guang village in People's Republic of China has within its vicinity 68 universities/colleges as well as over 230 state-level research institutes. Its tenants include over 6500 firms (Furuta 2001).

However, these technology parks are not limited to developing countries only. Such technology hubs have also emerged in developed countries, often through private efforts but mostly through a combination of private and government efforts. What are the preconditions for success of these hubs? Based on interviews with the local government officials and representatives of the business and the media, the *Wired Magazine* made an evaluation of the quality of about 50 leading technology hubs of the world. Each hub was rated according to four criteria revealing the factors that influence investors in their site selection: the ability of universities and research facilities in the area to develop new technologies and provide training opportunities; the presence of established firms and multinational companies; the entrepreneurial drive to start new ventures by the population; and the availability of venture capital to bring ideas to the market (Hillner 2000). As expected, those technology hubs in Asia that are rated highly are essentially those that belong to the higher-income countries with the exception of Bangalore in India.[5]

From the experiences of these special technological hubs, a number of important lessons seem to emerge. First and foremost, infrastructure matters and it should be easily available to ICT entrepreneurs if the country aspires to succeed in this area. The government has an important role to play in the provision of the infrastructure. Second, rather than trying to micromanage the private sector, the government should provide strong support to its growth by fostering an appropriate policy environment where entrepreneurship can flourish. Superior flexibility and autonomy are considered critical elements of a successful e-economy environment (Cohen, DeLong, and Zysman 2000). Third, the availability of human capital in the form of skilled workers is tremendously important for the success of such a park or hub. Finally, the ability to attract multinational companies and venture capital is likely to be critical in the successful growth of the location.

In light of the above, it is unlikely that all developing countries would succeed in developing special technology hubs. Nor should every country attempt to do so. Before attempting to undertake such a venture, each country should make a comprehensive evaluation of their true economic costs and benefits. In many cases, these technology hubs in developing countries could turn out to be enclaves of technological excellence and sophistication with little spillovers—technological or human capital—for the rest of the economy.

[5] This list includes some of the Asian cities: Taipei, Bangalore, Tokyo, Kyoto, Hsinchu, Hong Kong, Inchon, and Kuala Lumpur.

E. International Cooperation

In addition to national efforts, international organizations can play a role in promoting ICT in poorer countries.[6] A specific set of policy initiatives that international organizations could support to bridge the digital divide may include the creation of uniform standards through technical assistance and policy advice. However, premature standardization can become impediments to technological innovations. Second, in many developing countries, government monopoly predominates in the telecommunications sector. The international organizations can play a role in deregulating this sector as well as ensuring free entry of the private sector, including foreign firms. Also, as we have noted earlier, there are instances where there is an economic case for government subsidization or tax incentives. In poorer countries, where the government is fiscally constrained, international organizations can offer the necessary financial assistance to create the basic infrastructure, as the private sector—both domestic and foreign—may not be forthcoming for obvious economic reasons.

V. CONCLUSION

The advent of new types of ICT, in conjunction with globalization, has opened up fresh opportunities for economic and social transformations from which both developed and developing countries can immensely benefit. In this regard, two important features of new ICT have been emphasized. First, unlike previous technological innovations, access to new technologies—and the benefits they can bestow—can be almost immediate to developing countries. New ICT can be applied selectively and innovatively to directly enhance the welfare of the poor, although the existing data do not afford a full-fledged cost-benefit assessment (Quibria and Tschang 2001). Second, new types of ICT are likely to contribute toward a more efficient integration of the global labor markets than was considered possible before. While the forces of globalization are rapidly breaking down trade and investment barriers, new types of ICT are facilitating relocation of manufacturing and services industries more in line with comparative advantage across the world. The new types of ICT promote more efficient delivery of services, especially where such services can be digitized, and ensure rapid dissemination of market information. This process has the potential of bringing

[6] The increasing concern for the widening digital divide between the developed and developing countries has led to a flurry of activities in the international development community. The Group of 8 (G-8) countries have adopted the Okinawa Charter on the Global Information Society in its summit in July 2000 to assist developing countries in their efforts to narrow the digital divide. The G-8 created the Digital Opportunity Task Force (Dot Force) that includes stakeholders from G-8 and developing country governments, private and nonprofit sectors, and international organizations (DOT Force 2000). In the area of bilateral cooperation, Japan pledged to provide $15 billion in development assistance over five years to overcome the digital divide. International organizations like the Asian Development Bank and the World Bank have also placed special emphasis on ICT dissemination in poor countries in their list of priorities.

about a more seamless integration of the global labor markets—including those for unskilled workers—and elimination of absolute poverty.

Notwithstanding the immense potential of new types of ICT, many observers feel that the digital divide will not evaporate immediately or automatically. It is also felt that an aggressive strategy of investment in ICT, neglecting other critical developmental priorities, solely with the objective of eliminating the digital divide, may be counterproductive. Such a strategy will simply detract attention from the more fundamental developmental needs that many countries require to address on an urgent basis. They include such fundamental constraints to economic development as improving the basic infrastructure; opening up markets; breaking telecommunication monopolies; pursuing an effective legal and regulatory system; and providing education for all. For countries that try to skirt these problems, their efforts at computerization and Internet access may turn out to be mere wasteful investments—and indeed a recipe for financial disasters, given the scope for better use of scarce investible resources elsewhere in the economy.[7]

If governments in poor countries channel their scarce financial and political resources to developing social and human capital, building the basic infrastructure and creating a level playing field for the private sector, that will go a long way in creating the prerequisites for the ICT sector to flourish. Beginning modestly with such areas as data processing and teleworking, the poor countries can gradually move to more sophisticated tasks of software development and hardware innovation. Thus, notwithstanding the concerns voiced on the perils of being left behind in this digital age, developing countries should carefully balance between their conflicting needs of adopting modern technology and preparing the basic foundation for economic development.

[7] A recent study by Pohjola (2000) investigated the relationship between IT investments and growth in 39 countries over the period 1980-1995. It found that, whereas such investments boosted growth in developed economies, they were not beneficial in developing countries that lacked complementary policies.

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